UNIVERSITY OF CALIFORNIA
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AGRICULTURAL EXPERIMENT STATION
BENJ. IDE WHEELER, President
THOMAS FORSYTH HUNT, Dean and Director
H. E. VAN NORMAN, Vice-Director and Dean
University Farm School

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CABBAGE GROWING IN CALIFORNIA

By STANLEY S. ROGERS

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INTRODUCTION

The object of this publication is to give a few suggestions to the new settler and grower who is unaccustomed to the cultural requirements of cabbage under California conditions. As the local influences in this state are so variable, it is difficult to give specific directions for the culture of this crop which will be entirely applicable to every cabbage producing section. The investigations and observations here recorded have been carried on in the central and southern portions of California.

In the early history of vegetable growing in California, the production of cabbage was commonly mentioned. During the year 1886 an article appeared in the Pacific Rural Press in which the writer stated that the conditions found in California were very well adapted

for growing this crop and that as high as $800 per acre had been realized during the past year by some of the growers. During the season of 1899, there was approximately 8000 acres of cabbage grown in the vicinity of Colma, San Mateo County.

During the past ten years there has been developed throughout the east a large demand for California-grown cabbage, especially during the late winter and spring, when the eastern cabbage dealers are short of stock. Owing largely to better marketing facilities, the cabbage industry has grown rapidly until now there are annually shipped from California approximately 1000 cars. The future for this industry appears to be very encouraging, so that at the present time there is a large general interest in the cultivation of this crop.

EARLY HISTORY OF CABBAGE GROWING

[1]The Common Cabbage (Brassica olerasea) is probably a native of the British Isles and of the northern coast of the Mediterranean Sea. The date of its cultivation is very ancient, having been in general use prior to the Aryan Invasion, which dates back 2000 or 2500 years B.C. and used in its wild state for food at even an earlier date than this.

[2]"The wild cabbage as it still exists on the coast of England and France, is a perennial plant with broad lobed, undulated, thick, smooth leaves covered with a glaucous bloom. The stem attains a height of two and one-half to over three feet and bears at the top a spike of yellow and sometimes white flowers." From this original type the plant has changed, by selection and breeding, until it is now found in several forms such as the common solid head cabbage, cauliflower, Brussels sprouts, etc.

TYPES AND VARIETIES

C. L. Allen, in his book entitled, "Cabbages Cauliflower," divides the common cabbage into five distinct types: 1, the Flat head type; 2, the Conical shaped head; 3, the Savoy group; 4, the Red cabbage; 5, the Danish or Holland ball head. There are also numerous variations of these, some having special advantages such as extra early, partial resistance to extreme cold or heat, excellent storage qualities, etc. There is a large number of varieties of cabbage under cultivation, and Robinson in his book entitled "The Vegetable Garden" mentions over one hundred specific varieties, of which comparatively few are grown in California.

[1] De Candolle "History of Cultivated Plants." Page 83.

[2] W. W. Robertson, "The Vegetable Garden," pp. 117–118.

In the choice of a variety there are several factors that must be carefully taken into consideration such as the demands of the market, the season at which the crop is to be grown, type of soil, moisture conditions during the period of growth and the uses to which the crop is to be put. For one who is not thoroughly accustomed to the local conditions under which this crop is to be produced, it is always a good plan to consult with those in the immediate vicinity who have made a success of growing cabbage. The following list contains the names of the varieties which are commonly grown in California, together with a brief description of each.

Early Flat Dutch.—This variety is widely grown in California and is especially popular in the central portion of the state for the late winter and spring crop and for the manufacture of sauerkraut. The heads are large, flat, solid, of good keeping quality and they mature early.

Late Flat Dutch.—This variety is similar to the preceding, but matures more slowly and is commonly used for the mid-winter crop as well as for manufacturing sauerkraut.

Early Jersey Wakefield.—This variety is popular throughout California on account of its early maturing qualities. The heads are small and conical in shape.

Early Winningstadt.—This is a very popular variety and is one of the best for field culture. It is especially common in southern California for eastern shipments and generally commands the highest price on the market. As the young plants stand the heat well it is especially valuable for planting in the spring and summer. The heads are medium in size, conical, very solid, and their keeping qualities are excellent.

Early York.—This variety is grown commonly throughout California and is particularly well adapted for the early spring crop. The heads are oval, small and excellent in flavor, although not as solid as some of the other varieties.

Sure Head.—This variety is grown to some extent in this state. The heads are large, flat, solid, of good flavor and the keeping qualities are excellent. It is a late variety and an excellent shipper.

THE CABBAGE AS A TRUCK CROP

Due to the mild climate during the winter months it is possible, in many sections of the state, to mature a crop of cabbage at the season in which it is generally scarce in the colder portions of the United States, thus making the growing of winter cabbage for long

distance shipments especially remunerative. Cabbage, at this season of the year, is generally produced near the city of Los Angeles, and through certain parts of the Sacramento and San Joaquin Valleys. When grown as a truck crop, the average size planting varies from 5 to 40 acres. The markets for this crop are rather uncertain, in some years offering as high as $40 or $50 per ton for the grower, while in others, because of the uncertainty of the eastern markets, the prices are so low as to prohibit harvesting. The shipping season generally commences during November and lasts until April, May, or June. The Winningstadt is the variety commonly grown for winter cabbage, while the Flat Dutch or Early York are the popular spring varieties. The plants are set in the field from August to February. The soil for this crop should be well drained, especially in localities where winter rains are abundant.

THE CABBAGE AS AN INTER-CROP

Cabbage is grown extensively as an intercrop between young trees and where the conditions such as moisture and soil fertility are favorable this practice is recommended. The rows of cabbage should be at least four to six feet from the trees leaving sufficient space for the cultivation of the latter. Cabbage thus planted is generally grown during the winter months when the trees are in a semi-dormant condition and the amount of moisture in the soil is generally abundant for both crops. Where irrigation is practiced, it is very essential that enough water should be applied so that the trees do not suffer. Much of the cabbage in the southern part of the state grown for long distance shipments is produced under these conditions.

CABBAGE AS A MARKET GARDEN CROP

There is probably no market garden in the state in which cabbage is not grown during some season of the year. It is a common practice to plant cabbage for fall and winter use on the land which was used for growing early potatoes. If the demand for this vegetable is rather limited, the amount of cabbage grown should not be greater than the markets can handle and it is sometimes better to make two or three plantings at intervals of a month or six weeks apart, than to plant the entire area at one time. The ground in which the plants are to be set is generally heavily manured a short time before planting. In the market gardens along the coast, cabbage is generally grown through the entire year, but in the interior valleys the planting is done so that the crop will mature during the fall, winter and early

spring months. Other quick maturing crops such as lettuce etc., are often planted between the cabbage plants and harvested before the cabbage needs the land. The Flat Dutch, Early York, Winingstadt, and the Early Jersey Wakefield, are the most popular varieties for the market gardener.

SOILS

Cabbage will grow on soils ranging from coarse sand to adobe, but the character of the soil is one of the most important factors which determine the yield and quality of the crop. Soil well adapted for cabbage growing should be rich in potash and phosphoric acid, contain a good supply of humus, hold moisture well and be friable. The yield is usually larger upon the heavier types of soils, although occasionally during the winter when the rainfall is heavy a soil of lighter type may yield better.

Cabbage should not be grown the second time on the same land without a rotation unless the soil is exceptionally good in quality or has been heavily fertilized, because this crop is a heavy feeder.

MOISTURE

Cabbage requires a large amount of soil moisture throughout its entire growth, making irrigation necessary. Occasionally during the rainy season the plants receive too much water, and good drainage becomes necessary, for they may be injured as much by an excessive amount of moisture as by an inadequate supply.

Climatic Requirements.—Cabbage is one of the most hardy vegetables grown and will thrive during cold weather that would kill such crops as potatoes, beans and melons. It is therefore especially valuable as a winter crop and the land may be used for the more tender vegetables during the warmer season of the year. In growing this crop in the winter it is a very common sight to see the leaves covered with frost or with a thin layer of ice in the mornings with no apparent injury. The ability of the cabbage to stand heat is not nearly so great as its resistance to cold so that in the interior valleys it is difficult and often impossible to secure a head of good quality during the hot dry summers.

GROWING AND SUBSEQUENT CARE OF THE PLANTS

Hot-Beds.—When growing the young plants during the cold winter months it is necessary in some localities to start them in hot-beds. These should be constructed in a warm well drained place, preferably on the south side of a building or fence well protected from the

cold winds. They should also be situated so that they can be easily visited and, if possible, running water should be convenient for sprinkling. Of the several methods for construction of hot-beds, the following is commonly used by vegetable growers in this state. A pit should first be dug from one and one-half to two and one-half feet deep, five or six feet wide and as long as convenient. Around this should be built the sides of boards or cement, the one on the south six inches to one foot high and the north side from two to three feet in height with the ends connecting the sides. Place fresh horse manure, mixed with straw as it comes from the stable, in this excavation to a depth of from one to two feet, sprinkle and tamp thoroughly. In a few days the manure should be examined and if it is not heating evenly, it should be thoroughly forked over, tamped and rewet and after heating satisfactorily, covered from eight inches to one foot with soil of a sandy nature mixed with a heavy coating of well-rotted horse manure. After smoothing, the earth should be watered and allowed to remain in this condition for a few days before planting. The beds may be covered with glass sash, tule, grass mats or muslin; the last covering affording sufficient protection in most localities.

Seeding and Care of Plants.—The seed may be planted in a hot bed in drills from two to five inches apart and running the width of the bed or broadcasted. Under the right management either method is satisfactory. The main advantage of the former over the latter is that it gives an opportunity for cultivating the earth between the rows of plants. After planting, the seed should be covered from one half to three quarters of an inch with light well-drained soil or sand which will dry quickly and not bake and crack when wet. It will aid in germinating if burlap or muslin be laid on the soil until the young plants have reached the surface. After the plants have appeared at the surface, water should be applied in such a manner that the tops and surface of the soil will dry as quickly as possible. Watering should be done preferably in the morning when the sun is shining and it is better to water seldom but thoroughly than to apply small amounts often. After the true leaves have grown, the plants should be thinned wherever they are too thick, especially if the seed has been broadcasted. If the plants are growing in rows, the earth between them should be stirred thoroughly after each application of water. The covering of the beds can be removed during warm days and if the plants are to be set in the field directly from a hot bed, it should be entirely removed a few days before they are to be taken out. The taking off of the top however, should be gradual in order to accustom the plants to the exposure.

Removing the Plants from the Bed.—In order that the growth of the plants be checked as little as possible by transplanting they should be hardened off and lifted in such a manner that as many of the roots as possible may be preserved. The plants may be hardened off by stopping the irrigation a week or ten days before transplanting, and by gradually removing the cover until it has been entirely taken off a few days before the plants are taken out. There are two methods for lifting the plants from the beds: namely, pulling them up by grasping the tops in the hands, and by the aid of a trowel or shovel; the first method is commonly used by experienced growers and is satisfactory if the soil is in proper condition. For those who have had little or no experience the latter method will be found more satisfactory, as it is very important that the plants be removed in such a manner that the root systems will be but slightly disturbed, since the fibrous roots are necessary in order that they may become quickly established in the field. It will aid greatly in preserving the roots if the bed is thoroughly irrigated a few hours before taking out the plants. If the plants are large, the tops and the roots should be cut back leaving the latter one inch in length. If the plants have made too rapid a growth and are not stocky, they should be transplanted to cold frames before setting in the field. Figure 1 shows the result of removing the plants from the bed properly and improperly. The best method is one which will preserve as many of the small roots as possible, as illustrated in the plant appearing at the right. Figure 2 shows a large plant which has been properly trimmed back for transplanting.

Cold-Frames.—The cold-frame is probably more commonly used than the hot-bed for growing young cabbage plants and where the weather conditions are not too severe, this type of bed is recommended for the plants are thus more hardy and stocky. Cold frames may be built similarly to hot-beds, with the exception that no artificial heat is used and under ordinary conditions no pit is dug. The location of the bed, seeding, care of the plants, etc., are the same as in the case of the hot-bed, the main difference being that the growth of the plants is a little slower in this form of bed.

Growing the Plants in the Open.—In many sections of California the climate is so mild that it is not necessary to have the protection of even the cold-frame. Plants grown in the open are hardier and more uniform in size than when some protection is given so that this method of growing plants is advocated in preference to either of the former, provided the climatic conditions are suitable. These beds should be located in a warm, well-drained place, protected from

cold winds. The soil should be well drained, friable and of good quality. It is often advisable to spade under a heavy coating of well rotted stable manure a few weeks prior to planting in order to encourage a fast growth in the plants. These beds may be either

Fig. 1.—As many small roots as possible should be preserved when transplanting. Plant on right properly removed.

sunken or raised, the former type being used when growing the plants during the drier months. Sunken beds are generally three to four feet wide, four to six inches deep, and six to ten feet long, and the earth taken from these beds is thrown up to form a levee around each bed which aids in irrigating the plants. When planting the seed during the winter months and especially in locations where the rainfall is heavy, the raised beds will be found more advantageous, for the

drainage is better and the soil will warm up much more quickly than that in the sunken beds. Raised beds are made by making ridges ten to eighteen inches wide, four inches high and ten feet long. The thinning, irrigating, and removal of the plants when growing in the

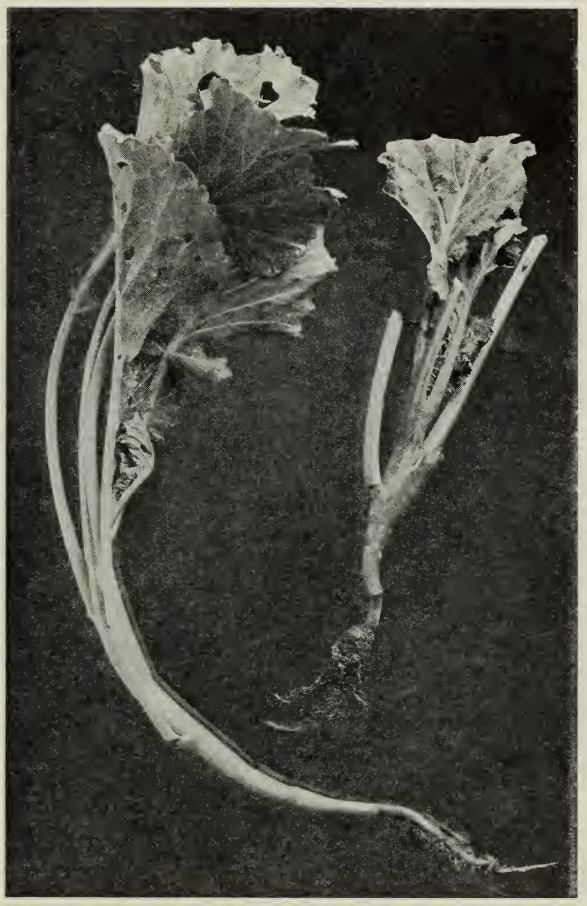

Fig. 2.—Large plant properly trimmed back for transplanting

open is practically the same as though the cold-frame or hot-bed were used.

TIME OF PLANTING AND QUALITY OF SEED

During the cold months the seed should be planted from eight to ten weeks before the time for setting out in the field, but when growing during the warmer season, they will often reach the desired

size in six weeks from the time of sowing the seed. The amount of seed required to grow enough plants for setting out one acre depends largely on the method necessary, the germinating power of the seed, and the variety. Under ordinary conditions from four to five ounces of seed will grow a sufficient supply of plants for one acre of land.

PREPARATION OF FIELD PREVIOUS TO PLANTING

In order that the young plants may start well after being set in the field, the soil should be in a good condition of tilth and free

Fig. 3.—Growing cabbage plants in the open

from weeds. When cabbage is grown as a market garden crop the soil generally receives manure at the rate of from fifteen to twenty-five tons per acre; as much as fifty tons being applied in some cases. The manure should be immediately plowed under to a depth of from ten to fourteen inches and the plants can be set out as soon as the manure has begun to rot. During the drier months the land is generally irrigated immediately after being manured. It is then plowed and occasionally a second application of water is beneficial. Just previous to planting, the soil should be thoroughly reworked to a depth of six to ten inches, by means of a disc or a heavy cultivator, followed by a harrow, clod masher, or ring roller. Where it is

advisable to fertilize before planting but impracticable to obtain manure, the following application of commercial fertilizer recommended by Professor Corbett, may be made:[3] 1200 to 1500 pounds per acre of commercial fertilizer containing 3½ to 4 per cent nitrogen, 6 to 8 per cent phosphoric acid, and 8 to 10 per cent potash. Just before planting the field should be marked off showing the location for the rows of plants.

Setting the Plants in the Field.—The average distance between the cabbage plants varies from two to two and one-half feet, the rows

Fig. 4.—Cabbages when transplanted are placed on the edges of the furrows

being from two and one-half to three feet apart; the exact distance depending largely upon the variety, upon quality of the soil and the water supply. If the distance between the plants is two by two and one-half feet there will be 8712 plants per acre, and 5808 plants to the acre if the distance is increased to two and one-half by three feet. During the drier months the plants are usually set on the edge of furrows down which water is run, as shown in figure 4. These furrows can be made with several of the cultivator attachments or with a single plow and are usually from three to five inches deep and six inches wide. When growing the plants during the winter

[3] "Garden Farming," p. 174.

in sections in which the rainfall is very heavy and especially when the soil is not well drained, these furrows or ditches are used for carrying off the surplus water. The plants should be set in the field a little more deeply than they grew in the seed bed, and in such a manner that their roots will not be twisted nor broken, and the earth should be packed firmly around every one in order to prevent the roots from drying. The transplanting is usually done by the aid of a trowel, spade, or "scandigie," the last implement being used principally by the Italians and it is especially adapted for this work.

Fig. 5.—"Scandigie" used for transplanting

Cultivation.— From the time the plants have commenced to grow until the leaves cover the ground, the field should be thoroughly cultivated and hoed, always preserving a fine mulch on the surface and prohibiting all weed growth. The earth should not be stirred too close to the plants nor too deeply after they are first set out as there is danger of injuring their roots.

Irrigation.—The exact number of times the cabbage fields should be irrigated depends wholly on the local conditions. During the fall and winter, irrigation is an exception but during the summer months the water may be applied as often as every ten days or two weeks. In order that the plants may make their maximum growth an optimum amount of water should always be present in the soil. Water is

generally applied by running it in furrows six to eight inches deep between the rows of plants. These furrows are made by the use of the lister, single plow or several of the various cultivator attachments. Enough water should be put on at each application, to thoroughly moisten the soil to a depth of from two to four feet. This is preferable to more frequent irrigations which wet only the top foot. Where water is easily and cheaply obtained, there is a tendency to substitute irrigation for cultivation, but this practice is not recommended for it is always better to preserve the moisture in the soil by thorough cultivation than by repeated irrigations. When cabbage is grown in the winter, the question of drainage is often more important than irrigation, for the crop may be seriously injured by an over-supply of moisture, especially after the heads have formed. This surplus water can often be removed by furrows similar to those used for irrigation.

HARVESTING

When harvesting, the field is generally gone over two or three times during the season as all of the heads do not mature at the same time and it is very essential that they be in proper condition before being cut. If cut before properly matured, the heads will be of inferior quality and will not keep well. If the cabbage is allowed to remain in the field too long the heads will "split" thus making them unmarketable. A properly matured head of cabbage should be firm, the outer leaves should be yellow, in color and their growth stopped. Cabbage, for long distance shipments, should not be trimmed as closely as that produced for local markets, for the outer leaves will protect the center of the head. Although cabbage will stand considerable rough handling it should be placed on wagons and cars in such a manner that it will not be bruised more than is necessary. After being cut the cabbage is hauled directly to the packing house, market, or storehouse.

STORING

In the central or southern portions of the state, storage is generally unnecessary as the crop is sold directly from the field. In the northern and mountainous sections it is often desirable and sometimes necessary to harvest the crop a considerable time before it is to be sold. When growing cabbage for storage a variety should be selected which will keep well and fully mature before harvesting. It should never be cut when frozen or wet, nor should it be trimmed as closely

as that cut for immediate consumption. Cabbage which is to be stored, should be handled very carefully, for every bruise is liable to start decay later on. Of the several methods of storing cabbage, the one most commonly practiced in California is that of a storage pit made by plowing a double furrow one and one-half by three feet wide and from twelve to fourteen inches deep. Cabbages to be thus stored are generally pulled up by the roots, the outer and dead leaves removed and the heads placed in the pits either on their sides or with the

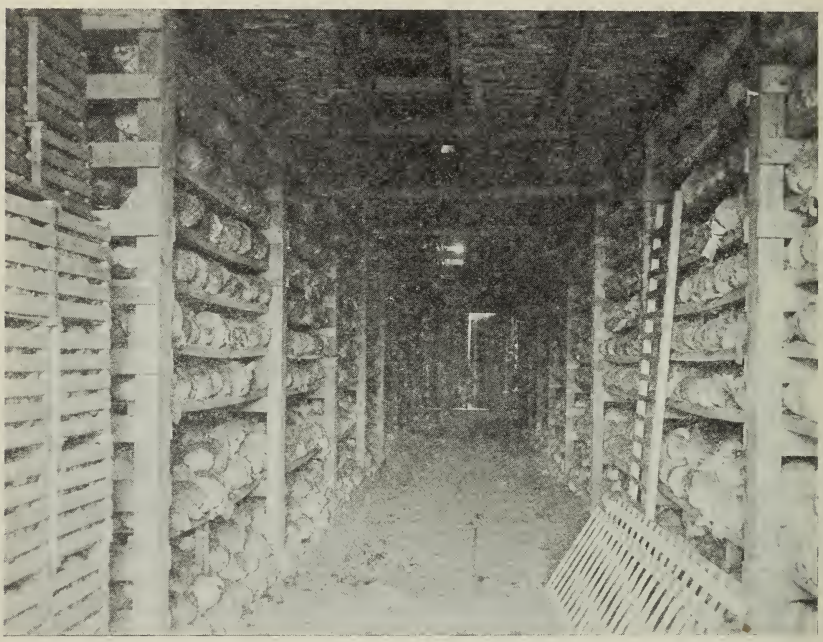

Fig. 6.—Interior of cabbage storehouse (after L. C. Corbett)

heads downward. Earth or straw or a mixture of both should be placed over them to a depth sufficient to give ample protection from the cold. The earth used for storing should be well drained and of a sandy nature. If a large amount of cabbage is to be stored a special building or shed should be erected which should be well ventilated, water-tight and warm. Professor Corbett[4] describes an ideal cabbage storehouse as follows:

"The general type of storage house is that of the broad, low structure with an alley in the center sufficiently wide to admit a team, as

[4] "Garden Farming," pp. 181 and 182.

shown in figure 6, and with the storage bins or shelves arranged on either side. If bins are used, they should be narrow and not more than sixteen or eighteen feet from the front to back, and the cabbage not more than six or seven feet in depth from the floor to the ceiling. Several bins may be placed one above the other in the same tier if there is a waterproof floor between them so that the drip from decaying cabbage or other moisture in one bin cannot reach the bin below. In general, the bins are not as satisfactory as the shelves. As is suggested in the illustration, the heads may be stored on the shelves in single layers or in two-layer, or three layer depths.'' When storing cabbages in houses the roots are cut off and the tops are generally trimmed more closely than when they are stored in pits. Professor Corbett[5] gives the following suggestions for keeping cabbage in storage.

''The secret of success in the management of a storage warehouse is to have disease-free, well-matured, firm, carefully handled stock grown from high-grade seed and a storage house so constructed that a temperature of about 34 degrees F. can be maintained throughout the whole storge period. This means that as soon as the house is filled, it must be kept closed during the day and open as much as possible during the night, so as to get the benefit of the low night temperatures. Every possible advantage must be taken of the frosty nights which occur during the storage period.'' Cabbage should never be taken out until ready to be shipped to the market.

MARKETING

When growing large acreages the most advantageous method of marketing is in carload lots through wholesale produce houses or associations. Cabbages thus sold may be loaded on the cars as dug out of the field or packed in crates, barrels or sacks. When a small acreage is grown, the crop may be hauled to the local market in wagons where it is sold directly to the retail dealer, which method is commonly practiced by the gardeners growing miscellaneous vegetables in the vicinity of the larger cities. The common form of packages in which cabbage is shipped is the New York crate, holding from 100 to 135 pounds, and a larger crate holding between 175 and 215 pounds, the cost of each being approximately 30 cents. Cabbage for the local market is commonly handled uncrated in the wagons and sold in this condition.

[5] *Loc. cit.*, p. 182.

COST OF PRODUCTION AND PROFITS

The average cost of production and profits to be derived from growing cabbage varies considerably, depending largely on the soil, season in which grown, and acreage management. The following table shows the average cost of raising one acre of cabbage under ordinary conditions. As the value of the land used for cabbage growing is so variable, the interest and rent are omitted.

Plowing 12 inches deep	$ 3.00
Harrowing	.30
Clod Mashing	.50
Furrowing for Planting	1.00
Seed	.60
Growing the Plants	2.00
Setting Out	5.00
Cultivating three times	1.50
Hoeing three times	6.75
Irrigating four times	12.00
Harvesting and Crating 12 ton crop	25.00
Fertilizing	20.00
Total	$77.65

The yield of cabbage in California varies from five to twenty-five tons per acre, the average being between eight and ten tons. When growing under more favorable conditions yields of from fifteen to twenty tons per acre are not unusual and occasionally yields of twenty-five tons are obtained.

The prices paid for cabbage varies from $5 to $40 per ton depending largely upon the season it is matured, and the eastern supply. From October to January the average prices which cabbage brings varies from $5 to $8 per ton; from January to March the prices are often uncertain and are dependent largely upon the amount of cabbage held over in storage in the eastern and northern portions of the United States. During these months, from $30 to $40 per ton is sometimes paid, although occasionally the values are so low that the crop is never harvested. As a general rule, the prices paid during the spring months vary from $10 to $20 per ton. The demand during April, May and June is generally light but occasionally at this season it finds a ready market at $20 per ton. The following table shows the net profit which should be expected in California when cabbage is grown under favorable conditions.

Average yield per acre	12 tons
Average price per ton	$ 10.00
Total gross returns per acre	$120.00
Average cost of producing one acre of cabbage minus interest on land	77.65
Average net returns per acre not deducting interest or rent	$42.35

As will be seen in the table showing the cost of production, $12 is estimated for the cost of irrigation and $20 is allowed for fertilizing. Where cabbage is grown during the winter the cost of irrigation is generally cut in two or omitted entirely and a large amount of cabbage is grown in California without the use of fertilizers. The figure which is given for the average net profits per acre is very conservative for sometimes the grower realizes as much as $100 net per acre.

DISEASES

Damping Off.—This disease is well known to cabbage growers in California and under certain conditions is the cause of large losses. It attacks the young plants while growing in the seed bed and is especially severe from the time the plants have appeared above the surface of the ground, until they have grown their true leaves. This trouble is first noticed by the appearance of a few dead plants scattered throughout the bed. Under favorable conditions the disease spreads rapidly from these infected areas until the entire seed bed has been destroyed. When a plant first becomes infected, growth stops and the plants turn a sickly yellowish color as though receiving insufficient nourishment. In a short time the leaves commence to curl, the plant falls over as if it had been cut off at the surface of the ground, and usually dies in a very short time.

Damping off is caused by several different fungi which live in the soil generally near the surface. These tiny organisms work into the stems and roots where they get their nourishment and cut off the circulation of food material through the plants. Like most other fungi they require moisture, warmth and shade to live and where these conditions are favorable, their growth is exceedingly rapid.

The successful control of this disease is preventive rather than curative in nature, for after a plant has become infected it is impossible to save it. The following recommendations are suggested for the prevention of damping off: 1, Avoid over-crowding the plants;

2, use soil which will drain easily; put a layer of sand or light loam on the surface; 3, irrigate in the morning so as to allow the tops of the plants and the surface of the soil to become dry by night; 4, irrigate seldom but thoroughly rather than putting on a small amount of water every day; 5, stir soil around the plants after each irrigation; 6, keep the beds well ventilated; 7, if disease has appeared isolate the affected areas by digging a furrow six inches deep, or pour formalin around them; 8, spray entire bed with Bordeaux Mixture, using three pounds of blue stone, four pounds of lime to fifty gallons of water; 9, if the disease has become established discard the bed and start a new one; 10, change the soil in beds each year, especially if damping off were present the previous season.

INSECT PESTS

Root Knot (*Nematode Worm*).—This trouble is characterized by the appearance of small galls or swellings on the roots, due to the invasion of pearly white bodies about the size of a pin head called Nematode Worms. When a plant has become infected, the leaves turn a yellowish, sickly color and the plants gradually die. Where the infection is very severe a large part of the root system will be found to be completely rotted off, similar to the one shown in figure 7. These worms live in the soil and attack the growing plants. Several methods of control have been recommended such as rotation of crops, fallowing, flooding and application of chemicals. It is very important that the earth used for seed beds be free from invasions of this pest.

Bursting.—The bursting of the heads is often troublesome, especially when the crop is maturing during the hot weather. This condition is also found when growth is too vigorous after the heads have formed or when it has been checked for a time. Certain varieties seem to be more susceptible than others to this condition. When planting cabbage which will mature during warm weather a variety which is partially resistant to heat should be chosen. When irrigation is practiced, the water should be applied in such a manner that the growth of the plants is regular, especially after the heads have commenced to form. If the plants are maturing too rapidly this can be partially overcome either by cutting off a portion of the roots or pushing over the plants with the foot.

Cabbage Worm (*Pontia rapae*).—These worms are commonly found in the cabbage fields of California and they are especially abundant during the warm weather. The first indication of their presence is

the appearance of holes in the outer leaves from which the worm gradually works into the heads, thus reducing their market value. The worms are of a yellowish green color and when full grown are

Fig. 7.—Cabbage affected by nematode worms
(after L. L. Harter)

a little over an inch in length. In two or three weeks from the time they are hatched, they change into chrysalids which may be found among the old bottom leaves. The white butterflies which are so commonly seen over cabbage fields emerge soon afterwards. The eggs

are laid by the butterflies on the cabbage and other plants and under ordinary conditions there are from three to four generations during the season. The most satisfactory method of control is by killing the

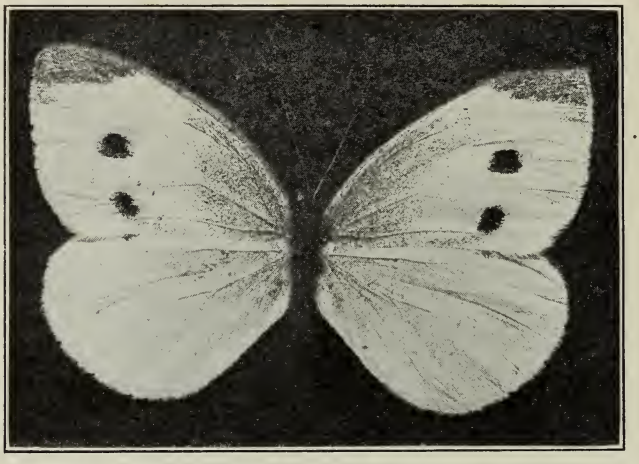

Fig. 8.—Female butterfly of the imported cabbage worm Pontia rapae (Linn) enlarged one and one-half times (after E. O. Essig).

worms as soon as possible after they have hatched out, using either of the following sprays:

I

Paris Green	1 pound
Air-Slaked Lime	3 pounds
Water	150 gallons

II

Black Leaf "40"	1 gallon
Whale-Oil Soap	4 pounds
Water	1000 gallons

Spray I can be used until the heads have commenced to form and from then on II should be applied. The spraying should be repeated as often as necessary in order to hold the worms in check and should be applied in such a manner that all parts of the plant above ground are thoroughly covered.

Aphis, (*Aphis brassicae*).—The cabbage aphis or cabbage louse attacks the plants during certain seasons of the year and is especially abundant during warm weather. They may be seen in large masses

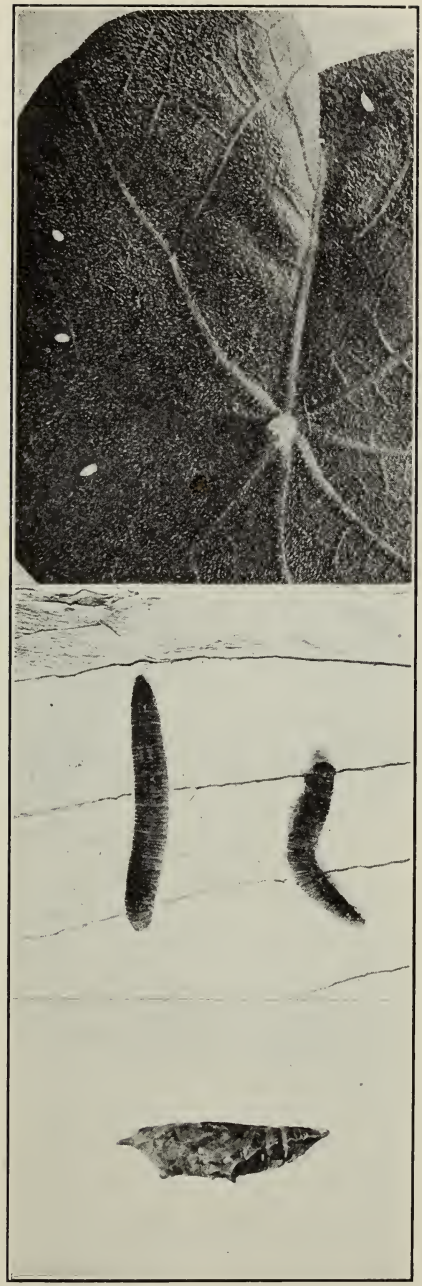

Fig. 9.—The imported cabbage worm Pontia rapae (Linn). Eggs on nasturtium leaf at top, enlarged twice; larvae in the middle, natural size; chrysalis at the bottom, natural size. (After E. O. Essig.)

on leaves and stems, are grayish-white in color, and are often covered with a waxy powder. When plentiful, the aphis weakens the plants and causes the leaves to curl. If the plants are attacked while young, the following spray will be found effective:

Kerosene (Coal Oil)	5 gallons
Laundry Soap	2 pounds
Water	100 gallons

If the plants have headed or are affected with the cabbage worm as well as the aphis, a nicotine spray (formula II) should be used.

Flea Beetles, Diabrotica.—Occasionally the plants will be affected by the Flea Beetles while growing in the seed bed or soon after being set out in the field. These can be successfully controlled by spraying immediately with Paris Green (formula I).

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